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REMOVAL OF Cr (VI) FROM WASTE WATER USING ROOT OF NEEM TREE

APARNA BHAWNANI[1] & S. K. GUPTA[2]

[1]*M. Tech Scholar, Department of Chemical Engineering, H. B. T. U. Kanpur, India*

[2]*Associate Professor and Head, Department of Chemical Engineering, H. B. T. U. Kanpur, India*

ABSTRACT

A novel adsorbent was prepared by using root of Neem Tree. The powder produced was characterized on the basis of surface morphology and specific surface area (854.52m2/g). Batch experiments were carried out to study the removal of Cr (VI) from synthetically produced chromium solution in laboratory. Three parameters were varied i.e. adsorbent dose, contact time and initial metal concentration. The data fitted well in Langmuir Isotherm with monolayer capacity of 20.36. The maximum removal efficiency was at lower concentrations. 5g/L of adsorbent dose was found optimum. Kinetics of removal was fast as equilibrium was reached in 60 min. Thus Neem Root adsorbent proves to be efficient and low cost for the removal of hexavalent chromium.

KEYWORDS: Adsorption, Eucalyptus Root, Langmuir Isotherm

ABBREVIATIONS

C_o ***initial concentration of solution (mg/L)***

C_e ***equilibrium concentration of solution (mg/L)***

q_e***amount of heavy metal per unit mass of adsorbent(mg/g)***

V_m ***monolayer capacity***

k Langmuir constant

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Original Article

INTRODUCTION

Heavy metals are metals which once entered human body, cannot be easily removed from it. These metals keep on getting piled up and may soon reach their maximum tolerable limit. So removal of these metals is of great importance. There are many heavy metals which are toxic like lead, arsenic, cadmium, copper, zinc etc. present study focus on removal of chromium (VI). Chromium (VI) is present in effluent stream of various industries such as mineral processing plants, metal-finishing, tanning etc.[1] Chromium exists in various oxidation states, but Chromium (VI) is known for its maximum toxic nature. Therefore, the world health organization (WHO) has established 0.05mg/L as a maximum allowable concentration of Chromium(VI) in drinking water.[2]

Various methods have been reported in literature for the removal of toxic heavy metals such as precipitation, ion-exchange, ultra-filtration, reverse-osmosis, Nano-filtration, electro-dialysis, adsorption etc. Of all these methods adsorption is the most convenient and cost-effective method which utilizes industrial and agricultural waste. These agricultural wastes are renewable and available at no or low cost. [3]

Present study uses root of Neem tree as adsorbent. Root is the part of plant that is not used because of its uneven shape and thus is a waste. Detailed batch study is carried out using modified Neem roots and following parameters are varied- contact time, initial concentration and adsorbent dose.

Table 1

S. No.	Metal Removed	Adsorbent Used	Reference
1.	Cr(VI)	Eucalyptus bark	Sarin and pant[1]
2.	Cr(III) and Cd(VI)	Alumina	Cervera and Arnal [4]
3.	Cu(II) and Zn(II)	Natural clay	Veli and Alyuz [5]
4.	Cr(VI)	Sawdust	Raji and Anirudhan[6]
5.	Cd(II)	Neem leaves powder	Sharma and Bhattacharya[7]
6.	Cu(II), Ni(II) and Pb(II)	Palm shell	Onundi et al [8]
7.	Cr(VI)	Activated Neem bark	Maheshwari and Gupta [9]
8.	Cr(VI)	Dried Pineapple leaves	Ponou et al [10]
	Cr(VI)	Fertilizer Industry waste	Gupta et al[11]
10.	**Cr(VI)**	**Neem Roots**	**Present Study**

MATERIALS AND METHODS

Preparation of Adsorbent

Neem roots were collected from nearby village. The roots are washed repeatedly with distilled water to remove dust and external impurities. The roots were then dried in a hot air oven at 70^0C for 24-48 hours and were powdered. This powder was treated with phosphoric acid (H_3PO_4) in the ratio of 1:1 by weight and kept for digestion in hot air oven at 105^0C for 1 hour and then carbonized in muffle furnace at 450^0C for 1 hour. The activated carbon thus produced was washed with distilled water and 1N NaOH to bring the pH of filtrate to 6. The washed activated carbon is dried in hot air oven at 100^0C for 5 hours. The activated carbon produced was stored in air tight bottles.

Adsorption Experiments

A stock solution of Cr (VI) is prepared by dissolving 2.8287g of 99.9% potassium dichromate ($K_2Cr_2O_7$) AR grade in 1000 ml of double distilled water to make stock solution The stock solution is diluted to prepare various solutions of different concentration. Calibration curve was plotted by using UV Spectrophotometer. Batch study is the best way to study the adsorption process. All batch experiments were carried out to find out the optimum adsorbent dose, contact time and effect of initial metal concentration. Firstly a known sample of chromium (VI) was prepared in a reagent bottle and to it a fixed amount of adsorbent was added. The reagent bottle with adsorbent was kept in an orbital shaker for a fixed amount of time and at fixed speed. After that time contents of the reagent bottle were filtered using what-man filter paper No. 42. The residue on filter paper was dried and stored for further testing and the filtrate was tested in UV spectrophotometer. Percentage removal was calculated.

$$\% \text{ removal} = \frac{C_0 - C_e}{C_0} \times 100\%$$

Where C_0 is the initial concentration of the chromium solution in mg/L And C_e is the final concentration of chromium after adsorption which is determined from calibration curve on the basis of absorbance in mg/L

The Langmuir Isotherm

Langmuir isotherm describes quantitatively the buildup of a layer of molecules on the adsorbent surface as a function of adsorbed material in the liquid phase which is in contact with the adsorbent. Langmuir assumed that the surface contains active sites to which adsorbate sticks. Langmuir isotherm is simplest of all approaches and is based on monolayer assumption. Once all the sites are filled with monolayer of adsorbent, the adsorption stops.

The linear equation of Langmuir Isotherm is given by:

$$\frac{c_e}{q_e} = \frac{1}{kV_m} + \frac{c_e}{V_m}[12]$$

Where q_e is the amount of adsorbed heavy metal per unit mass of adsorbent (mg/g)

V_m is the monolayer capacity

K is the equilibrium constant

C_e is the equilibrium concentration (mg/L)

RESULTS AND DISCUSSIONS

SEM and BET Analysis

SEM and BET result state that the adsorbent produced is highly porous with honeycomb like structure. Surface area per gram of adsorbent is high. Presence of more number of active sites ensures efficient adsorption. Micrographs at two magnification are presented below.

BET Result	
Surface Area	854.52 m^2/g
Total pore Volume	0.4309cm^3/g
Mean pore diameter	2.0168nm

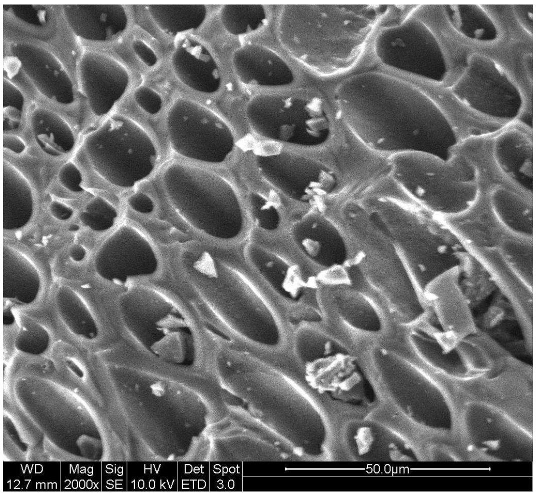

Figure 1: **SEM Image at a Magnification of 2000X**

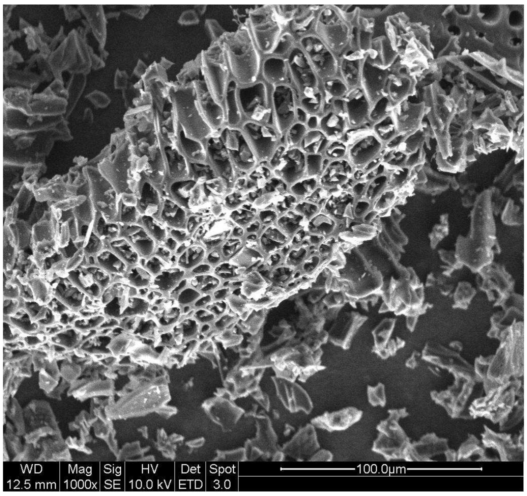

Figure 2: SEM Image at a Magnification of 1000X

Effect of Adsorbent Dose

The effect of adsorbent dose on adsorption of Cr (VI) was studied at an ambient temperature of (30±2℃) on 100 mL solution of initial concentration 100ppm at a constant speed of 150 rpm. The contact time kept constant at 40 min. the result obtained is presented below. It is evident from the curve that the percentage removal increases from 40% to 80.875%. It is apparent that the percent removal of chromium increases rapidly with increase in adsorbent dose due to greater availability of active sites or more surface area at higher adsorbent dose. The increase after 5g/L is negligible. Therefore optimum adsorbent dose is 5g/L.

Effect of Contact Time

Batch study of Chromium (VI) at different contact time is studied for 100 mL solution of initial metal concentration of 100ppm and adsorbent dose of 5g/L and keeping all other parameters constant i.e. ambient temperature of

30±2℃, contact time of 40 min. and shaking speed of 150rpm. The result is presented in the figure given below. It was found that an equilibrium time of 60 min was necessary to reach the equilibrium for Cr (VI) adsorption. A further increase in time didn't show any significant increase in removal of hexavalent chromium. The percentage removal increases from 70% to 88.125%.

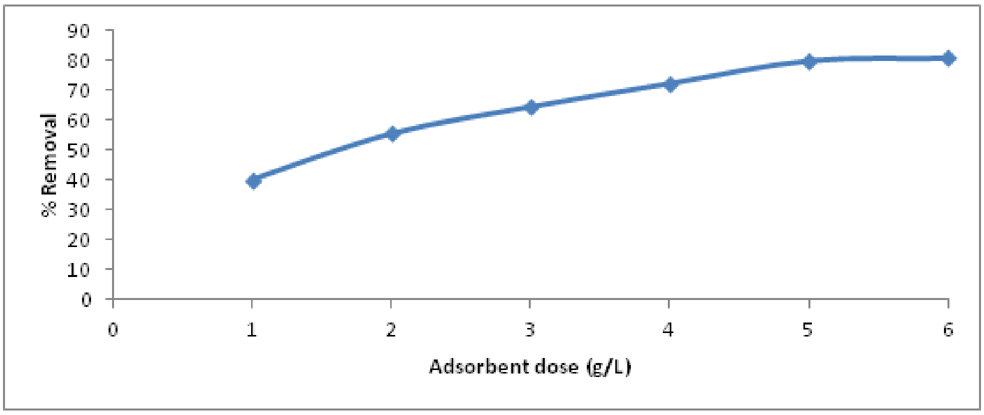

Figure 3: Effect of Adsorbent Dose 100ppm for 40min at 150rpm

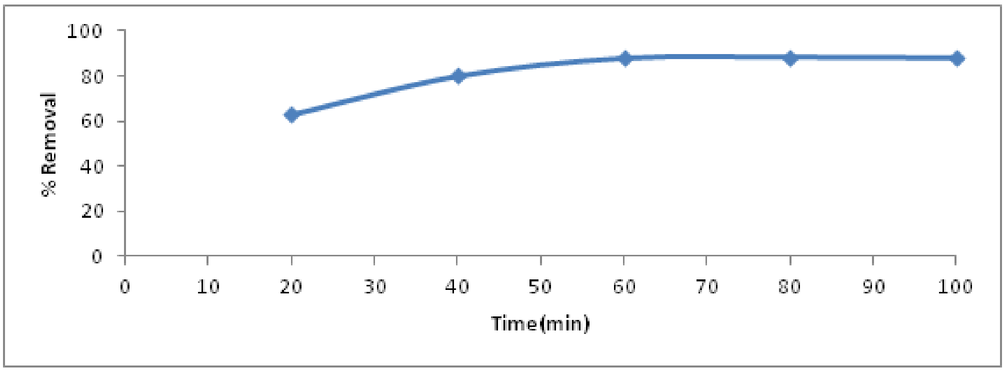

Figure 4: Effect of Contact Time for 100ppm at Dose of 5g/L at 150rpm

Effect of Initial Metal Concentration

The adsorption of hexavalent chromium on Neem root is studied by varying initial metal concentration. 100 mL solutions of different concentrations (50ppm to 250ppm) are taken in series of reagent bottles and optimum adsorbent dose of 5g/L is added to them. The ambient temperature of (30±2)℃, contact time of 40 min and speed of 150rpm are kept constant. The results are signified in graphical form % removal vs initial metal concentration. It is clear from the graph that % removal decreases with increase in initial metal concentration due to the fact that at greater adsorbate concentration active sites become overloaded. At low concentration, the ratio of sorptive surface area to total metal ions is high; so active sites have taken the metal ions more quickly. The %removal decreases from 81% to 38.2%.

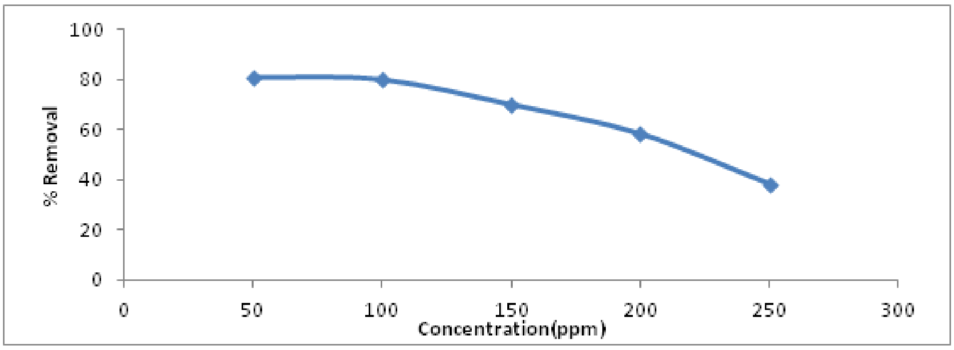

Figure 5: Effect of Initial Metal Concentration at 5g/L for 40 min at 150rpm

Langmuir Isotherm

Langmuir isotherm models the single coating layer on adsorption surface. The attraction between molecules decreases as getting away from the adsorption surface. [6]. The results obtained from the empirical studies were applied to Langmuir isotherm. The graph is plotted between C_e and C_e/q_e. The data is correlated with R^2 value of 0.963.

The linearized form of Langmuir correlation is given by $\frac{c_e}{q_e} = \frac{1}{kV_m} + \frac{c_e}{V_m}$

The obtained equations are as follows:

$$\frac{c_e}{q_e} = 0.2739 + 0.0491C_e$$

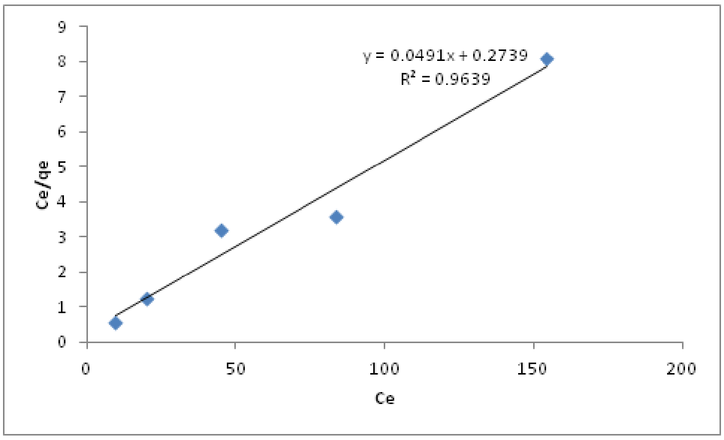

Figure 6: Langmuir Isotherm

CONCLUSIONS

The present study show that Neem Tree known for its medicinal properties can also be used for removal toxic Cr(VI) from effluent stream of industries. Neem roots prove to be efficient and low cost adsorbent for toxic Cr(VI). The efficiency was 88% for 100ppm solution at 5g/L adsorbent dose, 150rpm speed, 40min. contact time and ambient temperature of 30±2℃. From the above result it is clear that the material is appropriate for the removal of hexavalent Chromium from waste water.

REFERENCES

1. *Vikrant Sarin, K. K. Pant.2006. Removal of chromium from industrial waste by using eucalyptus bark. Bioresource Technology, 15-20.*
2. *Josiane Ponou, Jungah Kim, Li Pang Wang, Gjergj Dodbiba, Toyohisa Fujita. 2011. Sorption of Cr(VI) anions in aqueous solution using carbonized or dried pineapple leaves. Chemical Engineering Journal 172 906-913.*
3. *M. Sciban, M. klasnja, B. Skrbic. 2008 Adsorption of copper ions from water by modified agricultural by-products. Desalination 229. 170-180.*
4. *M. Luisa Cervera, M.carmen Arnal. 2003. Removal of heavy metals by using adsorption on alumina or chitosan. Anal Bioanal Chem 375. 80-825.*
5. *SevilVeli and Bilge Alyuz.2007. Adsorption of copper and zinc from aqueous solutions by using natural clay. Journal of Hazardous Materials 149. 226-233.*
6. *C Raji and TS Anirudhan.1997. Chromium (VI) adsorption by sawdust carbon: kinetics and equilibrium. Indian journal of chemical technology vol 4. 228-236.*
7. *Arunima Sharma, Krishna G. Bhattacharya.2005. Neam leaf powder as a biosorbent for removal of Cd(II) from aqueous medium. Journal of Hazrdous materials. 102-112.*
8. *Y. B. Onundi, A. A. Mamun, M. F. AlKhatib, Y. M. Ahmed. 2010. Adsorption of copper, nickel and lead ions from synthetic semi-conductor industrial waste water by palm shell activated carbon. International journal of environmental science and technology. 751-758.*
9. *Maheshwari Utkarsh and Gupta Suresh.2011. Kinetic and Equilibrium studies of Cr(VI) removal from Aqueous solutions using activated neem bark. Research Journal of Chemistry and Environment. 939-943.*
10. *Josianeponou, Jungah Kim, Li Pang Wang, Gjergj Dodbida, Toyohisa Fujita.2011.sorption of Cr(VI) anion in aqueous solution using carbonized or dried pineapple leaves. Chemical engineering journal. 906-913.*
11. *Vinod K. Gupta, Arshi Rastogi and Arunima Nayak.2010. Adsorption studies on removal of hexavalent chromium from aqueous solution using low cost fertilizer industry waste material. Journal of colloid and interface science.135-141.*
12. *N. Unlu, M. Ersoz. 2006. Adsorption Characteristics of heavy metal ions onto a low cost biopolymeric sorbent from aqueous solutions. Journal of Hazardous Materials. 272-280.*